The Pan-Pacific Entomologist

Vol. 41 April 1965 No. 2

Life History and Mating Behavior of *Tephritis stigmatica* (Coquillett)

(Diptera : Tephritidae)

Maurice J. Tauber and Catherine A. Toschi

University of California, Berkeley, California

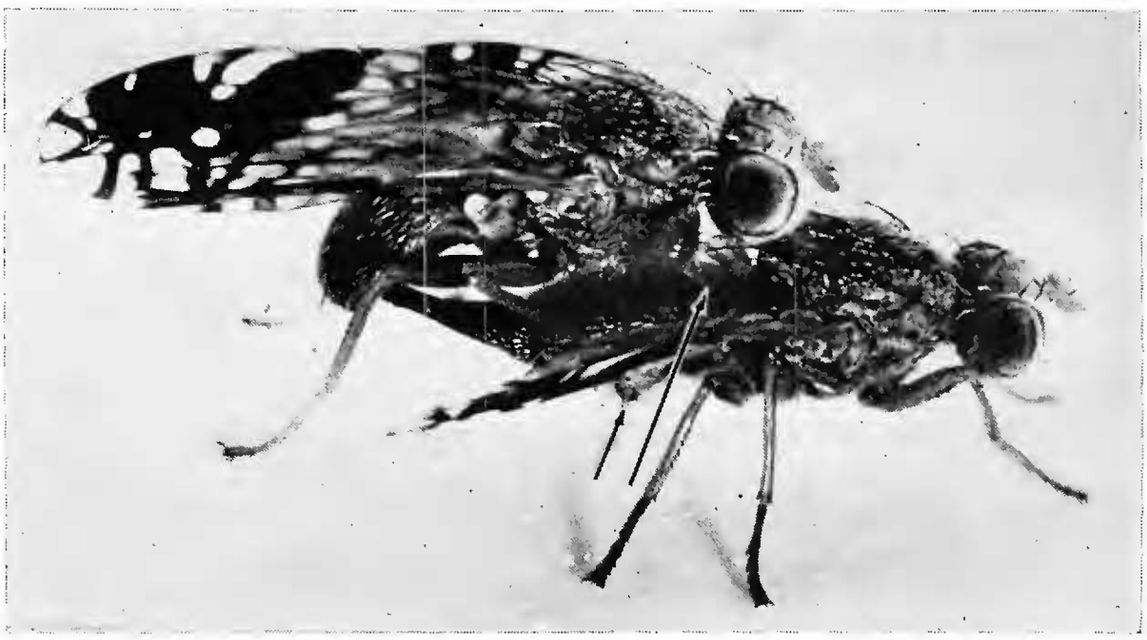
Tephritis is a genus of flies which is worldwide in distribution. Eleven species have been recorded from California and of these *T. stigmatica* (Coquillett) has the largest individuals (Foote and Blanc 1963). Foote (1960) published the most recent taxonomic review of the genus *Tephritis*. He gives the Western United States as the area of distribution of *T. stigmatica*. Foote and Blanc (1963) in their bulletin on California tephritids compiled the most complete list of collection and rearing records in California. *Senecio integerrimus* Nuttall, *Senecio douglasii* Candolle, and *Senecio* sp. are given as larval hosts. The adults are reported to have been collected from *Achillea* sp., *Chrysothamnus* sp., *Eriogonum* sp., *Grindelia* sp., *Lepidospartum squamatum* (Gray) Gray, *Medicago sativa* Linnaeus, *Pinus coulteri* D. Don, and *Pinus lambertiana* Douglas.

We found larvae in the composite host *Senecio integerrimus* at Sagehen Creek Wildlife and Fisheries Station. This locality has an elevation of approximately 7,000 feet and is about 12 miles north of Truckee, Nevada County, California. Flower heads containing larvae were collected on 27 June 1964 and the insects were reared in the laboratory.

This paper gives an account of the life history based on a single generation obtained from these plants. The mating behavior of *T. stigmatica* is described. This species shares some elements in its behavior with another tephritid *Euleia fratria* (Loew) (Tauber and Toschi, 1965). These activities are compared.

Life History

The head of *Senecio integerrimus* consists of many flowers each of which has a corolla. The young larva mines down one corolla to the ovary. After mining the ovary the larva moves laterally to the ovary of an adjacent flower. This lateral movement is repeated and results in



EXPLANATION OF FIGURE

Fig. 1. Copulatory position of *T. stigmatica*. The two arrows indicate fore and mesotarsi. Actual size of male is 10 mm.

damage to a localized area. Feeding by the older larva is largely confined to the ovaries, but the receptacle and the corolla also are slightly affected. The flower heads that we collected were usually mined by one larva, but some contained two to four larvae. When more than two larvae were present the damaged areas tended to merge. It was noted that multiple infestations were associated with large flower heads.

The puparium is usually found partly embedded in the receptacle. On occasion pupation occurs just below this region. However, in all cases noted, the longitudinal orientation of the pupa is vertical and the anterior end is up. Under laboratory conditions (temperature 24 ± 4° C; relative humidity 55 ± 8%) the time spent within the puparium is approximately 14 days. Samples of flowers were dissected beginning 27 June but puparium formation was not observed until 30 June. Adult emergence began on 14 July and was completed within 7 days.

Eighty-six adults were reared (49 females and 37 males). The days of initial and terminal emergence as well as the 3 days of maximum emergence coincided for the two sexes. This emergence pattern differs from that of *E. fratria* in that the males of *E. fratria* emerge earlier (Tauber and Toschi, 1965).

Adults were fed water, sugar, and enzymatic protein hydrolysate of yeast. The range of longevity was 6 to 187 + days.

PARASITES.—Four species of chalcidoid parasites were reared from *T. stigmatica* during this study. Two individuals belonging to the tribe

Table 1. Comparison of mating activities in *T. stigmatica* and *E. fratria*.

T. stigmatica	*E. fratria*
Activity (1), slight lateral wing displacement	Not observed
Activity (2), alternate wing wave initiated from midline of body	Alternate wing wave initiated after both wings are extended laterally
Activity (2), wing vibration during wing wave	No vibration during wing wave
Activity (3), dorsoventral movement of abdomen	Not observed
Male steps to one side while advancing towards female (rare)	Male and female step to one side and back again, while advancing (common)
Turning to face each other while on same plane	Same as *T. stigmatica*
Male and female assume "head up–tail down" stance (abdomen close to substrate, forelegs extended), wings parted; not seen in same context as in *E. fratria*	Male assumes "head up–tail down" stance, keeping body length orientated to moving female, wings fully extended laterally
Males court males, no attempted mounting	Males court and mount males

Merisini (Pteromalidae) and three specimens of *Tetrastichus* sp. (Eulophidae) emerged from puparia about 14 days after collection. After 8 months in the laboratory seven *Habrocytus* sp. (Pteromalidae, tribe Pteromalini) and one *Eurytoma* sp. (Eurytomidae) emerged from puparia. In all cases the hosts were taken from the field as eggs or larvae. The trophic relationship between these parasites and the fly is not known.

Mating Behavior

Males and females of *T. stigmatica* show a complex courtship display which consists of recurring, specific types of activity. These activities were observed when the insects were subject to natural and artificial illumination simultaneously. The courtship sequence is as follows:

Heterosexual behavior.—Activities (1), (2), (3), and (4) below are performed by both sexes.

(1) Both wings are moved laterally, at the same time, either to the left or to the right (i.e., like windshield wipers moving synchronously in the same direction). The angle of displacement from the longitudinal axis of the body is slight. The plane of the wings is parallel to the substrate. This act is more frequent at the beginning of courtship.

Table 2. Comparison of *T. stigmatica* and *E. fratria* copulatory positions.

T. stigmatica	*E. fratria*
Male	
Head held above female scutellum	Head above anterior abdominal nota of female
Mouthparts associated with dorsocentral bristles of female thorax	Not observed
Wings completely overlap	Wings parted
Fore tarsi along notal and pleural region of anterior segment of female abdomen	Fore tarsi along pleural region of anterior segments of female abdomen
Mesotarsi along pleural and sternal region of posterior part of female abdomen	Mesotarsi on substrate
Hind tarsi on substrate	Hind tarsi on substrate
Female	
Wings parted	Wings parted
Ovipositor telescoped	Ovipositor telescoped
Male and Female	
Both sexes quite separate except for these points of contact: female bristles, fore and mesotarsi, and genitalia	Male forecoxae appear to rest on female abdomen; male foretarsi and genitalia also in contact

(2) One wing at a time is moved laterally from the longitudinal axis of the body until it forms a 90° angle. As the wing passes laterally to or fro through the 45° point it vibrates rapidly. The plane of the wing is rotated so that it forms a right angle to the substrate, with costal margin up, when the wing is fully extended. The wing may be held in this pose for a few seconds or it may be returned immediately to the original position. In the meantime the other wing is held resting above the body. When the extended wing is returned it may either repeat the original movement or the other wing may repeat this movement.

(3) During activity (2) rapid dorsoventral movements of the abdomen are often seen.

(4) It appears that either sex makes the initial approach. When an individual passes within ½ to 1 inch of another of the opposite sex either one or both may turn and approach the other so that they come face to face. During the approach the male may take a few rapid steps to one side while still facing the female. Activity (2) continues throughout this performance. However wing movement is frequently in phase when the face to face position is assumed. That is, either both left wings

Table 3. Summary of *T. stigmatica* life history.

Species Distribution	Hosts	Egg Stage	Larval Stage	Puparium	Adult Longevity	Parasites
Western U. S. A.	*Senecio integerrimus* *Senecio douglasii* *Senecio* sp.	probably in corolla	mainly within ovaries	approx. 14 days; partly in receptacle	187 + days; on water, carbohydrate, enzymatic protein hydrolysate of yeast	*Tetrastichus* sp. Merisini *Eurytoma* *Habrocytus*

or the apposed wings (e.g., female left and male right) may be moved out and back, synchronously. It appears that courtship may be broken off as well as recur at any point along the above sequence.

(5) After a number of bouts of activity (4) the following may appear. The male moves closer to the female and she decamps. He follows her and attempts to copulate.

The copulatory position is shown in Fig. 1 and certain of its features are described in Table 2. We have observed individual *T. stigmatica* pairs to remain in copulation for at least 3 hours.

HOMOSEXUAL BEHAVIOR.—Activities (1), (2), and (3) are performed by males or females when they are reared in isolation from the opposite sex. In the presence of females, the males were also observed performing action (4). This was followed by disengagement. Males were never observed mounting males as was seen by Tauber and Toschi (1965) in the case of *E. fratria*.

DISCUSSION

A comparison of the activities found in the mating behavior of *T. stigmatica* and *E. fratria* in Table 1 reveals similarities and differences. Table 2 compares their copulatory positions.

Spieth (1952) surveyed the courtship and copulatory behavior of 21 species groups of the genus *Drosophila*. He states that some elements of their mating behavior are widespread but that qualitative and quantitative interspecific differences exist. A comparison of courtship patterns of *T. stigmatica* and *E. fratria* reveals such differences between the two species.

Qualitative characteristics present in *T. stigmatica* and absent in *E. fratria* are: wing movements as in activity (1), wing vibration during activity (2), and abdomen vibration as in activity (3). A qualitative

character present in *E. fratria* and absent in *T. stigmatica* is mounting of males by males.

Quantitative differences in the mating behavior of the two species are present in the wing waving movements, "side stepping" by the advancing male, and characteristics of the copulatory position (e.g., *T. stigmatica* holds the female abdomen with two pairs of legs rather than one pair).

Feron (1962) investigated specific stimuli involved in the mating of the Mediterranean fruit fly *Ceratitis capitata* Wied. He found that both males and females react to chemical stimuli and that the males react to visual stimuli as well. The specific stimuli leading to successful mating in *T. stigmatica* have not been investigated. However, we can try to relate the discrete courtship actions with the category of stimuli that they might subserve.

Wing vibration during activity (2) and abdomen movement in activity (3) may serve to produce *auditory stimuli.* Waldron (1964) has shown that sound production is significant in the mating behavior of certain *Drosophila* species. It is conceivable that auditory as well as visual stimuli could, for example, be implicated in keeping male and female wing movement in phase during activity (4).

The precise and immediate orientations of either sex to its partner, the wing display, and the "side step" during activity (4) strongly suggest that vision plays an important role in mating. In the case of the "side step" the male while changing his direction of movement remains oriented to a motionless partner.

Chemical stimuli have been implicated in the behavior of other tephritids (Feron, 1962). Spieth (1952) in his consideration of *Drosophila* speculates that wing action by the male could direct odorous substances towards the female. In *T. stigmatica* wing movement could also serve this function in both sexes.

Summary

The known life history of *T. stigmatica* is summarized in Table 3. This table is styled after Christenson and Foote (1960) who may be consulted for comparison with 14 other tephritids. For comparison with *E. fratria* see Tauber and Toschi (1965). The mating behavior of *T. stigmatica* has been described. A comparison was made between the courtship display and copulatory position of *T. stigmatica* and those of *E. fratria.* Stimuli which may be involved were discussed.

ACKNOWLEDGMENTS

We want to thank Dr. J. A. Powell for reading the manuscript and Drs. Ray F. Smith and W. W. Allen for encouragement. Dr. F. R. Cole determined the fly and Dr. G. I. Stage determined the parasites. The help of Miss Theresa Toschi is acknowledged with thanks. This work was done during the appointments of C. A. T. as a Hilgard Scholar and of M. J. T. as a University Fellow.

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